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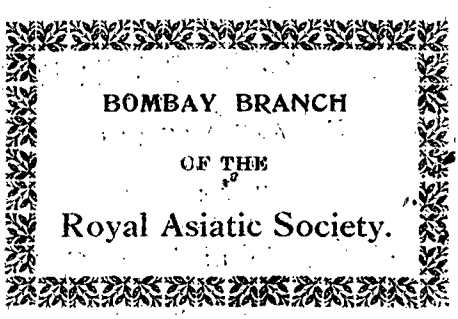

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SUEZ CANAL.

REPORT

OF

108396

JOHN HAWKSHAW, F.R.S

TO THE

EGYPTIAN GOVERNMENT.

3rd FEBRUARY, 1863.

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33, *Great George Street,*
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3rd February, 1863.

TO THE EGYPTIAN GOVERNMENT.

In the month of July last, His Highness the late Viceroy of Egypt, when in England, requested me to visit Egypt, and examine the site of the proposed Ship Canal, intended to connect the Red Sea and the Mediterranean, across the Isthmus of Suez, and to report my opinion of that work to the Egyptian Government.

At the end of October last, in obedience to that request, I proceeded to Egypt, and arrived in Alexandria on the 12th November.

I then proceeded to Cairo, and immediately on my arrival there had an interview with the Viceroy, who then explained to me that he desired my opinion not only on the Suez Canal, but also on the projected Basin and Graving Dock and works connected therewith, at Suez, these being undertakings wholly unconnected with an independent of the former.

The Secretary of His Highness, H.E. Koenig Bey, had already written to M. de Lesseps and the Engineers and Agents on the Canal, desiring them to afford me the fullest information on every point, and to facilitate my enquiries by every means in their power.

Four Egyptian engineers were appointed to accompany me, *viz.:*

H.E. Mazhar Bey, who for twenty years has been engaged on the works of the Nile and the various Canals leading from it.

Salameh Effendi, who had been employed on the original surveys of the Canal.

Ismail Effendi and Abol Mejdi Effendi, two engineers employed by the Government.

Accompanied by these gentlemen, who have no connection with the Company established to construct the canal, I proceeded to Suez, where I was occupied three days in verifying the soundings in the Red Sea at the proposed southern entrance to the canal at Suez, in examining the site of that entrance, and of the proposed basin and graving dock, and in visiting the quarries,

at Attaka, from whence stone is being obtained for the basin and graving dock, and from whence it was at one time intended to obtain stone for the jetties of the northern or Mediterranean entrance to the canal at Port Said.

I was met at Suez by M. Stoecklin, the engineer charged with the construction of the basin and graving dock, who accompanied me in my investigation, and afforded me every information.

Leaving Suez, I travelled across the desert along the line of the proposed ship canal to Port Said. There I remained three days, testing the soundings, examining the site of the proposed works, and about 8 leagues (20 miles) of adjacent coast, including the communications (Boghazes) between the sea and Lake Menzaleh, at Gemileh, to the westward, and at Oum Fareg to the eastward of Port Said.

I then left Port Said in one of the Viceroy's steamers, and proceeded by sea to the Damietta mouth of the Nile, taking soundings of and examining that part of the coast as I went: the steamer's course being generally about 1½ leagues (4 miles) from the shore.

From Damietta, I passed up the Nile to the palace of the Viceroy at Benal' Assal, where I had another interview with His Highness. I then proceeded to Cairo.

At Timsah, the most southern point to which the works of the ship canal have yet extended, I was joined by Mr. Lange, a Director and the English representative of the Company; by M. Villers, the engineer of that section of the canal works extending from Timsah to Lake Ballah; by M. Laroche, the engineer of the works between Lake Ballah and Port Said; and by M. Cazeau, the engineer of the works of the Fresh Water Canal. These gentlemen accompanied me over the works, and M. Laroche went with me to Damietta, where I had an interview with M. Voisin, the engineer-in-chief of the undertaking, and M. Larousse, hydrographical engineer to the Company. Mr. Lange accompanied me as far as Cairo.

At Cairo, I again embarked on the Nile, and passed down that river by the Rosetta branch to Rosetta. Afterwards I again ascended the Nile as far as Foueh, where I entered the Mahmoudieh canal, and proceeded along it to Alexandria.

At Alexandria, I examined the old and new harbours, and travelled along the sea shore on each side of those harbours to the westward beyond the quarries at Mex, and to the eastward into the bay of Aboukir, returning to Alexandria along the shore of Lake Madieh.

In Alexandria, at the general offices of the Company, I met M. Ferdinand de Lesseps, the president; M. de Chancel, one of the directors; and Mr. Lange. I received the greatest attention to all my enquiries from these gentlemen; and I think it due to them, as

well as to the engineers and other officers of the Company, to state that every question was answered in the frankest manner, and that every document I asked to see was without the slightest hesitation shown to me.

I was occupied twenty-seven days in examining the district traversed by and adjacent to the canal, and of so much of Lower Egypt as appeared to me likely to throw light on the subject under consideration; and having completed this portion of the investigation, I returned to England.

I had been put in possession of the results arrived at by previous labourers in the same field of enquiry, and I have read all that has been written that appeared to me worth reading on the important subject under consideration.

I may name the following as being the most important of these documents, viz.:—

The report of the International Scientific Commission, and the subsequent correspondence of its members.
The reports of Captain Spratt., R.N., C.B., F.R.S.
The reply of M. Mougel Bey to the reports of Captain Spratt.
The observations of the late Mr. Robert Stephenson.
The various reports of the Canal Company.
The report of the Commission appointed by His Majesty the King of Holland to enquire into the consequences of the construction of the canal.

The labour of investigating so large a question has been much lightened by the vast amount of research that previously had been bestowed upon it.

GENERAL DESCRIPTION OF THE SUEZ CANAL, OF THE ISTHMUS OF SUEZ, &c.

The undertaking of the Company charged with the execution of this canal is shown upon Plan No. 1, and comprises,—

1st. The construction of a Ship Canal from the Red Sea at Suez to the Mediterranean at Port Said.
2nd. The construction of a Fresh Water Canal from the Nile near Cairo to Timsah, and thence to Suez.

In connection with the Fresh Water Canal, the Company have

purchased for 2,000,000 francs (£80,000) the tongue of land (coloured dark green on Plan No. 1), containing about 11,330 hectares (28,000 acres), extending from Abbacèh to Ras El Wadé, and as part compensation for their outlay on this work, they have the privilege of cultivating as much land on each side of the Fresh Water Canal as they can find means to irrigate, paying to Government the same tax upon it as is charged on the other cultivated lands of Egypt.

Between Cairo and Abbacèh there appear to be no lands worth cultivating by the Company, but they are of opinion that interest on that portion of the expenditure may be made by disposing of water for irrigation purposes to the adjoining landowners.

From Ras el Wadé to Suez the Company calculate that in twenty years 50,000 hectares (123,555 acres) may be cultivated by means of the Fresh Water Canal.

Before proceeding to notice the works, it may be worth while briefly to describe the district traversed by the canal, and its relative position to other portions of Egypt.

Egypt comprises that portion of the basin of the Nile extending from the cataracts to the Mediterranean, a distance of about 250 leagues (625 miles).

That part of it under cultivation consists, above Cairo, of a narrow strip extending on each side of the Nile, the length of which strip is about 200 leagues (500 miles), and the breadth 2 to 3 leagues (5 to 7½ miles); and below Cairo, of a triangular plain, bounded on two sides by straight lines extending, on the one hand, from Cairo to Port Said, on the other from Cairo to Alexandria; the Mediterranean forming the base or third side of the triangle.

This triangle of cultivated land constitutes the valuable portion of Lower Egypt. It is bounded east and west by deserts, which consist of extensive plains of sand and gravel.

Cairo, which forms the apex of this triangle, and Suez, which is at the southern extremity of the proposed canal, are both in the same parallel of latitude (about 30°), Suez lying 35 leagues (about 87 miles) to the eastward of Cairo.

From Cairo, and from the western shore of the Red Sea a promontory of higher land juts out, which extends to the margin of the Bitter Lakes. This promontory is indicated by the calcareous mountains of Amoun, Awebet, Attaka, and Généffé, the latter mountain forming its north-eastern extremity.

In that part of the Isthmus of Suez, extending from the Red Sea to the Mediterranean, there is a remarkable valley or depression of the soil. Beginning at the upper end of the Red Sea this depression passes from Suez round the north-eastern side of the mountain of Généffé by El Ambak, Serapeum, Timsah, El Guisr, and

Kantara, to Port Said, and sinks in places below the surface of the Red Sea and of the Mediterranean; it is now a fact established beyond the possibility of doubt, that the relative level of these two seas is very nearly the same.

The lowest parts of this depression constitute the basins of Lake Menzaleh and Lake Ballah, and also the basins (now usually dry) of the Bitter Lakes and Lake Timsah, and along this depression runs the course of the ship canal.

The sand of the Isthmus nearly along the whole line of the canal is strewed with shells of the same species as those now found in the Red Sea and the Mediterranean, and it is evident that at no distant period, geologically speaking, those seas occupied the place which is now proposed to be devoted to the ship canal.

The only two points along its course where the land rises much above the level of the two seas are at Serapeum and El Guisr (*see* Plan No. 4), the highest point at the latter place being 18 metres (59 feet), and the former 11 metres (36 feet) above their mean level.

The basins of the Bitter Lakes contain considerable deposits of salt, and the only wells I met with were brackish. Those were near El Ambak.

WORKS OF THE CANAL ALREADY EXECUTED.

The Company have already constructed so much of the Fresh Water Canal as extends from Ras el Wadé to Timsah. This work comprised about 1,000,000 cube metres (1,308,000 cube yards) of earthwork, and has been completed according to the statement of M. Cazeau, the engineer of this portion of the work, for 700,000 francs (£28,000). The cross section of the Fresh Water Canal is shown on plan No. 5, Fig. No. 5. The workmen had commenced when I was there to extend this canal towards Suez.

As respects the Ship Canal, the Company have, partly by dredging in Lake Menzaleh, and partly by excavating between that lake and Lake Timsah, opened a water communication between the Mediterranean and Timsah, sufficient for flat bottomed boats of small draught of water. The sections of this communication, showing its capacity compared with the full sized canal, is given in Plan No. 5, Figs. Nos. 3 and 4.

The Company have also made a commencement at Port Said,

having executed a small portion of the western sea jetty: and they have also at Port Said, El Guisr, and Timsah, built houses, workshops, and provided plant and machinery to a large extent.

The expenditure on work done, land purchased, houses and workshops built, plant and machinery provided, amounted on the 1st December, 1862, according to the statement furnished to me by M. de Lesseps, to 49,600,000 francs (£1,984,000). This sum M. de Lesseps reduces, by certain deductions, to 30,500,000 francs (£1,220,000), which he takes to represent the net expenses in works and general charges. I give the account as it was handed to me.

Approximate Statement furnished to me by M. de Lesseps of the Expenses of the Canal of Suez up to the 1st December, 1862.

"The report made to the General Meeting of the Shareholders, on the 1st May, 1862, shows the general state of the account of receipts and expenditure up to the 31st of March of that year.

The expenses may be distributed as follows, in round numbers :—

		Francs.	£
I.	Expenses prior to the formation of the Company, viz.: drawings, travelling expenses, purchase of plant, &c. .	2,900,000	116,000
II.	Land, &c. — The Ouady Estate . . .	Francs. 2,000,000	
	Warehouses at Damietta. .	50,000	
	Ditto at Cairo .	200,000	
		2,250,000	90,000
III.	Furnishing offices in Paris and Alexandria	100,000	4,000
IV.	Interest paid to Shareholders . . .	7,350,000	294,000
V.	Ordinary expenses of management in France and Egypt	3,500,000	140,000
VI.	Personal expenses, and salaries of engineers	1,200,000	48,000
VII.	General expenses of works, plant, commissariat, and transport . . .	22,500,000	900,000
	Total expenditure to 31st March	39,800,000	1,592,000
	Say . . .	40,000,000	1,600,000

		Francs.	£
Brought forward		40,000,000	1,600,000
At the present rate of carrying on the works, the necessary expenses of the Company are about 1,200,000 francs (£48,000) a month, which would give from 1st April to 1st December		9,600,000	384,000
Total expenditure to 1st Dec. 1862		49,600,000	1,984,000
From which is to be deducted:—			
I. The cost of land (which is recoverable)*	Francs. 2,250,000		
II. The interest from temporary investments of funds in hand, which is added to the capital of the Company	6,500,000		
		8,750,000	350,000
Leaving the general expenses of management, purchase of plant, provisions, carriage, and works of every description, up to 1st December, 1862, in round numbers, at . .		41,000,000	1,640,000
The plant is represented in this sum by about . .	Francs. 8,000,000		
to which may be added the cost of construction of buildings, about . .	2,500,000		
		10,500,000	420,000
Net expenses in works and general charges		30,500,000	1,220,000

* The Ouady Estate alone, let out to Arabs, has this year brought in to the Company a net revenue of 149,000 francs = £5,960.

Alexandria, 5th Dec. 1862.

Delegated Administrator,

(Signed) T. DE CHANCEL."

Along the whole course of the Ship Canal there is no fresh water, and Suez itself has to be supplied from Cairo. It is brought by the railway, along which large trains conveying iron tanks filled with water, are constantly passing. The men employed on the works had to be supplied from similar tanks placed at intervals along

the line of operations, which were filled from casks carried by camels from the nearest point where fresh water was procurable.

The extension of the Fresh Water Canal, from Ras el Wadé to Timsah, became therefore of great importance. The conveyance of fresh water from Timsah, to the district intervening between that place and the Mediterranean, will be facilitated by the canal communication already established; and it is intended, as speedily as possible, to lay water pipes from Timsah to Port Said. It is also important, as soon as may be, to extend the Fresh Water Canal o Suez.

WORKS OF THE CANAL REMAINING TO BE EXECUTED.

These are as follows :—

1st. The extension of the Fresh Water Canal from Timsah to Suez.
2nd. The extension of the Fresh Water Canal from Ras el Wadé to Cairo.
3rd. The completion of the Ship Canal between the two seas.

1*st. The extension of the Fresh Water Canal from Timsah to Suez.*

This mainly consists of earthwork. The earth is being excavated from the bed of the canal and carried to the sides.

The length of that portion of the Fresh Water Canal, extending from Timsah to Suez, will be about 80 kilometres (50 miles). M. Cazeau, the engineer, is of opinion that, with a sufficient supply of men, he can complete it by the end of May, 1863.

When I visited this work about 9,000 men were employed upon it. It would require more than this number to complete it in the time named; but as it is important to finish it as soon as possible, it is the intention of the Company to concentrate their force upon it. If the requisite number of men are supplied, there is no reason why it should not be completed in a few months.

The estimated cost of this section of the Fresh Water Canal is 3,500,000 francs (£140,000), which is based on the cost of that portion of the work already performed, and may be divided as under :—

	Francs.	£
Works	2,500,000	100,000
General expenses . . .	1,000,000	40,000
	3,500,000	140,000

This section of the Fresh Water Canal passes near to, and on the north-eastern side of, the mountain of Généffé, and the material of this mountain, which is calcareous rock, is well adapted for building purposes and for the formation of the sea jetties. When finished there will be a water communication not only from Généffé, but also from Suez viâ Timsah to Port Said. It is intended to convey the stone for the jetties at Port Said from Généffé along this canal, and hence the importance of its immediate completion. The portion of the western jetty at Port Said already executed, has been constructed of stone conveyed by sea from the quarries at Mex, which is more costly than if the stone were brought from Généffé.

A collateral advantage of the completion of this section of the Fresh Water Canal will be, that the inhabitants of Suez, and the shipping and the railway locomotive establishment at that place, now dependent on water carried from Cairo, a distance of 145 kilometres (90 miles), will be put in immediate connection with a Fresh Water Canal from the Nile.

2. *The extension of the Fresh Water Canal from Ras el Wadé to Cairo.*

The Fresh Water Canal from Ras el Wadé to Cairo will be 90 kilometres (56 miles) in length, and is estimated to cost 3,500,000 francs (£140,000). The Company have not yet determined when they will commence this portion of the work. It cannot however be long delayed, because until it be completed the supply of water to the finished portions of the Fresh Water Canal must be taken from the Nile by the existing conduits, which become dry or nearly so at Low Nile; the Fresh Water Canal therefore cannot be perfect until it is put in proper communication with that portion of the Nile above the Barrage, nor indeed until the Barrage which is still incomplete, is finished.

3. *The completion of the Ship Canal between the two seas.*

It will be gathered from what I have already said, that only a small portion of this work has been performed. Between Suez and the northern end of Lake Timsah nothing has been done. Between the northern end of Lake Timsah and Port Said the comparative amounts of earthwork done and to be done, as shown on cross sections Nos. 3 and 4, plan No. 5, are approximately as follows;

	Cube Metres.	Cube Yards.
Earthwork done . . .	6,000,000	(7,848,000)
Earthwork to be done .	26,000,000	(34,000,000)

and at Port Said, as already explained, only a small portion of the Western Jetty has been executed.

The completion of the Fresh Water Canal to Suez, which in connection with the water communication just opened between Timsah and Port Said, would afford means of transit along the whole course of the works, as well as of a ready supply of water to the workmen, seems also a necessary preliminary to the construction of the greater work. In a district where there are neither houses, tools, nor workshops, it became necessary to incur a large expenditure and to occupy a considerable time in providing these requisites.

The work of the Ship Canal consists of three descriptions :

a. Earthwork to be excavated from the bed of the canal and carried to the sides.

b Dredging in the bed of the canal north of Timsah, and in the Red Sea and Mediterranean entrances.

c Stone jetties at Port Said, and stone pitching or other protection of portions of the slopes of the canal.

The stone jetties originally contemplated at the entrance to the Red Sea have been abandoned. It is now proposed to dredge a channel at that place of sufficient capacity for ships. This is shown on plan No. 2.

A reference to the plans and sections accompanying this report will enable the extent of the works to be better understood. Beginning at Suez, a channel will be dredged into sufficiently deep water. The mouth of this channel is to terminate to the southward of the entrance to the basin and graving dock, now constructing for the railway and steam packet traffic. The portion to be dredged will average 5 metres (16½ feet) deep.

Between the upper end of this dredged channel and the Bitter Lakes is a distance of 20 kilometres (12½ miles), and the canal between these points will be wholly in excavation, varying from 9 metres (29½ feet) to 17 metres (55¾ feet) in depth.

The canal will pass through the Bitter Lakes for about 38 kilometres (23⅔ miles).

Between the Bitter Lakes and Lake Timsah the canal will be in excavation for a distance of 13 kilometres (8 miles) the depth of the cutting in this length varying from 9 metres (29½ feet) to 19 metres (62 feet).

It will then pass through Lake Timsah for a distance of 4½ kilometres (2¾ miles), the excavation of this part averaging about 8 metres (26 feet) deep.

At El Guisr, which lies between Lake Timsah and Lake Ballah,

a distance of 18 kilometres (11¼ miles), the canal encounters the highest ground. The depth of the excavation between these two lakes will vary from 9 metres (29½ feet) to 26 metres (85 feet).

From the south end of Lake Ballah to Lake Menzaleh is a distance of 18 kilometres (11 miles), and the depth of excavation between these points will average 9 metres (29½ feet.)

The canal then passes through Lake Menzaleh, and with small exceptions the ground throughout this lake is below the level of the sea. The distance between the south end of Lake Menzaleh and Port Said is 32 kilometres (20 miles), and the depth of excavation will average 7½ metres (24⅔ feet).

The works at Port Said (*see* plan No. 3) will consist of a basin 800 metres (875 yards) square, and of an eastern and a western stone jetty extending into the sea. The eastern jetty will be 3,300 metres (3,609 yards) long from the coast line, and the western jetty 2,300 metres (2,515 yards) long, and the distance between the two is is to be 400 metres (437 yards).

The channel between these jetties is to be dredged to a depth averaging 3½ metres (11½ feet) below the present surface.

The canal between Suez and the Bitter Lakes was originally intended to be 100 metres (328 feet) wide, and 80 metres (262½ feet) wide between these lakes and the Mediterranean. The width between the Bitter Lakes and the Mediterranean is now intended to be 58 metres (190 feet). The reduced width between the Bitter Lakes and Suez is not yet determined upon, but it will probably be 80 metres (262½ feet). The length of the canal, from sea to sea, will be 145 kilometres (90 miles).

If the canal had been constructed of the original dimensions, the quantity of work to be performed would, according to the report of the International Commissioners, have been as follows:—

1. Ship Canal—

	f. c.	Francs.	Cost of each Work. Francs.
Dry earthwork, 46,000,000 cube metres (60,168,970 cube yards) at	0.67	30,820,000	
Earthwork under water, 50,177,926 cube metres, (65,633,786 cube yards) at	1.00	50,177,926	
Stone pitchings, 496,364 cube metres, (649,254 cube yards) at	8.00	3,970,912	
Fixing dunes and for ferries		400,000	
Total Ship Canal (carried forward)			85,368,838 (£3,414,754)

	Cost of each Work. Francs.
Brought forward	85,368,838 (£3,414,754)
2. Fresh Water Canal	9,000,000 (£360,000)
3. Harbour of Said	21,059,075 (£842,363)
4. Harbour of Timsah	1,589,120 (£63,564)
5. Harbour of Suez	8,649,562 (£345,982)
6. Miscellaneous Works— Including lighthouses, harbour lights, beacons, working stock for quarries, tools, &c., storehouses, buildings, hospitals	2,335,000 (£93,400)
Total of works for constructing the canals	128,001,595 (£5,120,063)
7. Accessory Works— Including fixing the dunes, cultivation of granted lands, electric telegraph, steam towing stock, careening and refitting dock	15,850,000 (£634,000)
Total estimated expenditure on works	143,851,595 (£5,754,063)
To this has been added in order to determine the actual Expenditure—	
Expenses of Administration, estimated at 2½ per cent. on the capital	3,578,164 (£143,127)
A sum for omission and casualties, estimated at about 10 per cent. of the expenditure, according to the estimates	14,570,241 (£582,810)
Grand total of expenditure for the works	162,000,000 (£6,480,000)
Leaving for the payment of 5 per cent. on the capital, during the execution of the works, and for the formation of accessory establishments destined to augment the profits of the Company	38,000,000 (£1,520,000)
Total capital of the Company	200,000,000 (£8,000,000)

Borings have been taken at distant intervals along the whole line of the canal, and these, as far as they go, show that the excavation will be through sand, argillaceous sand, or clay. Persons, however, who are conversant with engineering works know what little confidence can be placed in borings unless they are taken very frequently, and even then they sometimes lead to fallacious conclusions. Should it happen that rock be encountered instead of sand and clay, in any of the places intervening between the spots where the borings were made, then the excavation of such material under water would be at least twenty times as costly as dredging clay or sand, and would not only augment the cost, but would extend the period of completion and add to the difficulty of execution. But the existence of rock will be of no important consequence where the excavation can be executed dry, that is to say, by open cutting; for the uses to which stone on the spot could be applied, unless it should be met with to a much greater extent than I think probable, would compensate for any increased cost of excavation.

In the description I have given of the general outline of the country, I have pointed out the rocky promontory which, starting at Cairo, and on the shores of the Red Sea, projects itself in a very visible manner as far as Généffé. As I passed the mountain of Généffé, I saw evident signs of its rocky roots, extending eastward beneath the covering of sand towards the course of the canal. Therefore between Lake Timsah and Suez, it is possible that beds of rock underlying the covering of sand may be met with.

It appears to have been in contemplation to execute some of the excavation between Lake Timsah and Suez, by dredging. So much of the sea entrance at Suez as lies under the sea level must be so performed. When, however, the Fresh Water Canal is completed to Suez and to Cairo,* a water communication will be established with Port Said sufficient for the transit of materials, and there will be no reason whatever, why the whole of the excavation required to form the canal between Lake Timsah and the margin of the Red Sea, should not be executed in the usual manner without having recourse to dredging.

I am of opinion, that this portion of the canal ought to be executed by open excavation, for two reasons—firstly, because the contingency which I have pointed out, of having to excavate rock under water, would thereby be avoided; and, secondly, because having regard to the time of completion as well as to probable cost, there is already such a large amount of excavation to be performed by dredging between Lake Timsah and Port Said, and at the sea entrances, as to make it very desirable to execute the remainder of the work by open excavation.

* I say to Cairo, because without this the Canal would be short of water in dry weather.

It does not appear that, between Lake Timsah and Port Said any great risk will be run of encountering rock within the depth to which the dredging will have to be carried.

As regards the passage of the canal through the Bitter Lakes, I may observe that those lakes, when filled with water, will present a surface 40 kilometres (25 miles) long, and about 8 kilometres (5 miles) broad, and I think it will be necessary to embank the canal through that portion of the lakes in which excavation will be needed to form the canal of the requisite depth, for otherwise there might be difficulty in confining ships to a narrow channel, sunk below the bottom of the lakes, in a situation where the expanse of water, and consequent exposure, would be so great as it will be in these lakes.

It was a question discussed by the International Commissioners, whether, throughout the whole extent of the Bitter Lakes, one side of the canal should not be embanked. If such a work be required, it would be needed only to protect the shipping from the winds; and the practical working of the canal will alone solve the question whether, and to what extent, protective works, beyond those I have already suggested, may be needed. I am of opinion, nevertheless, that the wiser course to pursue will be, to reckon on expenditure in this respect, and to assume that the canal, to be perfect, will require guiding and protecting works of some kind, through the whole of the Bitter Lakes. The execution of these works is only a question of cost, and involves no other difficulty.

The estimate of the International Commissioners, for the whole undertaking, was, as has already been stated, 200,000,000 francs, or £8,000,000.

By reducing the width of the canal between the Red Sea and the Bitter Lakes, from 100 metres to 80 metres, and from 80 metres to 58 metres between the Bitter Lakes and Port Said, 25,000,000 cube metres (32,700,900 cube yards) of earthwork will be saved.

On the other hand, I am of opinion that the slope of the Ship Canal below sea level, which is proposed to be 2 to 1, is insufficient; and, I think, that the benching intended to be 2 metres wide, upon which it is intended to place the stone rubble for protecting the sides of the canal against the wash of the water, is too narrow. I think the canal, below the water line, will require a slope of at least 3 to 1, and that the benching on each side should not be less than 5 metres (16½ feet) wide.

I have shown this alteration on cross sections Nos. 1 and 2, plan No. 5; it would reduce the saving of earthwork before mentioned to 12,000,000 cube metres (15,696,000 cube yards), amounting to 12,000,000 francs (£480,000).

I have stated that I deem it safer to assume that the canal will have to be protected through the Bitter Lakes. For this purpose, 7,000,000 francs (£280,000) should be added to the estimate.

On account of the velocity the current will sometimes there attain, it is probable that the bottom and the banks of the canal, from the Red Sea to the Bitter Lakes, will require to be pitched. This velocity may, under the extremely rare combination of circumstances (which could only last for a short interval of time), produced by a gale from the south, with the highest equinoctial spring tide, amount to 1·16 metres (3·80 feet) per second, the velocity at high water neap tides being 0·60 metres (2 feet) per second: and between these extremes, the velocities at high water will vary. Unless, therefore, the bed and banks of the canal be of very stiff clay, sufficient to resist abrasion from the water running at the highest velocity, they will have to be pitched with stone. This pitching may cost 12,500,000 francs (£500,000).

Respecting the channel now to form the approach to the canal at Suez (which is in a different position, and longer than the one intended to have been formed in connection with the abandoned stone jetties), it may be remarked that it is, in deep water, a difficult operation to cut out a given section with precision by dredging. From the nature of that kind of work, something more than the net calculated quantity should be assumed; and I do not think it safe, considering this and the other contingencies, and the increased quantity of dredging to be performed, to calculate on any saving in the cost of construction, by adopting the dredged channel now proposed, and abandoning the jetties formerly proposed.

The International Commissioners did not feel that they had had sufficiently long experience in Egypt to enable them to determine the prices of the work. They appear, therefore, to have delegated this portion of their task to M. Mougel Bey and M. Linant Bey, two French engineers, who had for a long time been employed in Egypt, and who were acquainted with the value of work in that country. In this respect, I am no better fitted than the Commissioners were, to determine with accuracy, so important a matter. I have had, it is true, what they could not have, *viz.*—the benefit of the experience which the gentlemen entrusted with the direction of the works have since acquired. But as it respects the deep dredging in the canal and its entrances, where unforeseen contingencies are most likely to occur, even they have hitherto had no experience.

M. Voisin, M. Villers, M. Laroche, and M. Cazeau, the engineers of the Company, who have hitherto been conducting the works, stated to me that they saw no reason, judging from their past experience, to doubt that the prices of the different descriptions of work,

adopted by the International Commissioners, were not sufficient; and, as far as my inquiries go, I see no reason, except as to the dredging, to differ from their conclusions on this point.

The very important item of expenditure, *viz.*—that of interest to shareholders, will depend on the time of completion. M. Voisin was of opinion, that with 30,000 men the canal could be completed in three years. Supposing the funds to be found as fast as requsite, then, from the nature of the work, it is a question of the number of workmen and the number of dredging machines. As it regards number of men, however, His Highness, the late Viceroy, informed me, that he considered 20,000 would be as many as could be spared from the agricultural and other occupations of the country.

For the purpose of executing the dredging, the Company now possesses twenty-four dredging machines, each capable of lifting about 400 cube metres (523 cube yards) per day, and twenty additional machines are ordered, which are to have greater power, each being calculated to lift 1,000 cube metres (1308 cube yards) per day. But assuming these forty-four dredging machines to lift only 25,000 cube metres (32,700 cube yards) per day, they would, if worked 300 days in a year, raise 7,500,000 cube metres (9,810,000 cube yards) per annum.

Supposing the canal between Lake Timsah and the Red Sea to be excavated dry, then between Lake Timsah and Port Said, and at the entrances into the Red and Mediterranean Seas, there will be about 40,000,000 cube metres (52,321,000 cube yards) of excavation to be performed by dredging, which, at the above rate, will require about 5½ years to complete.

As regards the entrance from the Red Sea, I am of opinion that, apart from the possibility of meeting with rock below sea level, the formation of a channel by dredging alone is, on the whole, the best course to pursue, and that it is as well to have abandoned the jetties; and although no saving in first cost may be thereby made, yet the expense of maintenance will probably be lessened. The dredging will be carried to the deep water where the Indian steamers now lay at anchor, and a good and accessible port will be established by the means contemplated. If rock be met with it will increase the time within which the work could be executed, and will add to the cost. It is possible, however, that more borings may remove all doubts on this subject.

The dredging and the formation of the jetties at Port Said will probably be the measure of the time of the completion of the canal. The dry excavation will be simply a question of number of men. Supposing, therefore, that there are 50,000,000 cube metres (65,400,000 cube yards) of dry excavation to be performed, this would be equi-

valent to 33,333 cube metres (43,600 cube yards) per day distributed over 5 years.

And assuming that the jetties at Port Said will contain 1,000,000 cube metres (1,308,000 cube yards) of stone, this would require 333,333 cube metres (436,000 cube yards) per annum for 3 years, or 110 cube metres (144 cube yards) per day, which would be accomplished by 5 flat-bottomed boats, carrying 30,000 kilogrammes (30 tons) each, daily, between Généffé and Port Said.

MAINTENANCE OF THE CANAL.

This important subject, involves the consideration of two questions—the first being an engineering question, and the second a traffic and revenue question.

With the second question I (as an engineer) have nothing to do, further than as it may be affected by the conclusions arrived at as to the first.

As regards the first question it has been urged—

1. That the canal will become a stagnant ditch.
2. That the canal will silt up, or that the moving sands of the desert will fill it up.
3. That the Bitter Lakes through which the canal is to pass, will be filled up with salt.
4. That the navigation of the Red Sea is dangerous and difficult.
5. That shipping will not approach Port Said, because of the difficulties that will be met with, and the danger off that port on a lee shore.
6. That it will be difficult, if not impracticable, to keep open the Mediterranean entrance to the canal.

I will proceed to notice these several objections:

1. It has been urged that the canal will become a stagnant ditch.

This objection has, I presume, reference to some assumed liability consequent upon the absence of current for the canal to silt up, or to some assumed difficulty (arising from the same cause) of keeping open the sea entrances, or probably to both these consequences.

As far as the absence of current is concerned, the Suez Canal, supposing it were without stream, would only resemble canals in England, Holland, and elsewhere, which might with equal propriety be called stagnant ditches. The very object indeed sought to be attained in the construction of canals in England, is by means of locks and similar contrivances to dam up pools of water which practically have no current.

Absence of current (though favourable to navigation) will no doubt lead to silting in every case where the water holds matter in suspension, which requires motion to keep it from settling to the bottom; and the degree to which this silting takes place varies in proportion to the quantity of such material held by the water.

The Suez Canal, however, will not be entirely without current. The International Commissioners, fearing apparently that there might be too much current, went into calculations, and arrived at the conclusion in which I concur, that between the Red Sea and the Bitter Lakes, the highest degree of velocity which the water can attain along the bottom of the canal, and which could only be for a short interval of time under very exceptional circumstances, will, as before observed, be 1·16 metres (3·80 feet) per second; and between the Bitter Lakes and the Mediterranean the highest velocity will be 0.35 metres (1·14 feet) per second. This latter current however in ordinary times will doubtless be small; but it does not follow, even supposing there were no current at all, that its non-existence (whilst it would be beneficial to the navigation) would to any material extent be detrimental to the maintenance of the canal. This will appear from what follows:

2. It has been urged that the canal will silt up, or that the moving sands of the desert will fill it up.

The rise of equinoctial spring tides above the mean level of the sea at Suez is 1.12 metres (3·67 feet). When accompanied by strong southerly gales they rise to a maximum height of 1·64 metres (5·38 feet). In the Mediterranean the equinoctial spring tides rise only 0·13 metres (·42 feet) above the mean level of the sea at Port Said, but when accompanied by strong northerly gales they rise to a maximum height of 0·56 metres (1·83 feet.)

The superficial area of the canal between the Red Sea and the Bitter Lakes, assuming it to be 80 metres (262 feet) wide at the mean water level, will be 1,609,000 square metres (1,924,000 square yards), and the superficial area of the Bitter Lakes, which are 5 leagues (12½ miles) from Suez, is 330,000,000 square metres (394,691,000 square yards). Looking to the large area of these lakes, compared with the length and size of the conduit which will connect them with

the Red Sea, it is probable that the level of the Bitter Lakes will not be much raised by mere tidal action, but will correspond very nearly with the mean level of the Red Sea. The occurrence of northerly or southerly winds may however affect the level of these lakes as of other portions of the canal.

The tidal action at Suez, consisting of an alternate elevation and depression of the water with reference to the mean level of the sea, would lead to an oscillating current into and out of the canal, which would alternately raise and lower its level as far as the influence of the tide extended, which for all practical purposes may be assumed to be as far as the Bitter Lakes only. This would produce not only an inward current, but also an alternating outward current of nearly the same velocity as the former. The same action from the like cause, though in a much smaller degree, will obtain at the Mediterranean end of the canal. It is probable that the action of these alternating currents will be to carry out as much sedimentary matter as they bring in.

The evaporation, assuming it to be equal to something less than 1 centimetre (·39371 inch) per day, will amount in one year approximately to say 3 metres (9·8427 feet). This, in that portion of the canal extending from Suez to the Bitter Lakes, inclusive of the area of the lakes, would amount to 995,000,000 cube metres (1,300,000,000 cube yards), and assuming half this amount for infiltration, the total loss of water on this section of the canal would be 1,492,500,000 cube metres (1,950,000,000 cube yards) per annum.

Similarly, the evaporation from the canal between the Bitter Lakes and the Mediterranean, assuming it to be 58 metres wide at the mean water level, will be 15,000,000 cube metres (19,600,000 cube yards), and assuming half this amount for infiltration, the loss of water on this section of the canal would be 22,500,000 cube metres (29,400,000 cube yards) per annum.

If the deficiency of 1,492,500,000 cube metres (1,950,000,000 cube yards) between the Red Sea and the Bitter Lakes were made up, as it is likely it would be, from the Red Sea, and if the deficiency of 22,500,000 cube metres (29,400,000 cube yards) between the Bitter Lakes and the Mediterranean were made up from the Mediterranean, it would create a current from those seas into the canal, but the currents arising from these sources would be small.

But the deficiency arising from evaporation and infiltration, representing the quantity of water that would flow into the canal, would give the measure (if the precise quantity of the sedimentary matter it contained could be arrived at) of the total silt that could be deposited in the canal from these occurrences.

The water of the Red Sea contains less sedimentary matter than that of the Mediterranean at Port Said, and indeed for all practical purposes it may be said to be free from it. Assuming that the water, finding its way into the canal from the Mediterranean, contained one-fourth as much sedimentary matter as that of the Nile water, or 0·001, which is a large assumption, then the annual amount of deposit from this occurrence would not exceed 22,500 cube metres (29,500 cube yards).

The other source from which it has been apprehended the canal may be filled up, and which it has been thought might prove the most prominent cause of mischief to the navigation, is the moving sands of the desert.

From Suez to the northern end of the Bitter Lakes, those sands lying adjacent to the canal are generally so compact, being often covered with small gravel, as to prevent their shifting in any important degree, and there will be no moving sands to affect the canal where it passes through Lake Timsah, Lake Ballah, and Lake Menzaleh.

The only portions of the canal therefore, likely to be affected by drifting sand, are those which will extend from Lake Timsah to Lake Ballah, about 22½ kilometres (14 miles) in length, and a portion near Serapeum, say for about 14 kilometres (8½ miles) in length. Altogether, the portion of the canal liable to be so affected will not exceed 36½ kilometres (22½ miles).

M. Villers, who is the engineer of the works of the canal from Lake Timsah to Lake Ballah, and where the excavation of the canal has already been formed of sufficient depth to arrest moving sand, informed me, that from the 1st January to the 23rd November, 1862, 30,000 cube metres (39,000 cube yards) only of blown sand found their way into the canal, and he was of opinion, that when the works were completed this quantity would be greatly diminished, and I certainly see no reason why it should be increased.

Assuming a proportionate quantity to that measured by M. Villers to find its way into the canal in the other 14 kilometres (8½ miles) near Serapeum, the total amount of deposit from this source would be about 47,500 cube metres (62,000 cube yards) in a year.

But in addition to this, some sand will find its way into the canal from the slopes. Assuming the quantity of deposit from this source to be equal to that from blown sand, then the total quantity arising from drifting sand, and from the slopes, and from the sea water that enters the canal, to make up the loss from evaporation and infiltration, will amount to 117,500 cube metres (153,500

cube yards) annually. Supposing however, that the quantity should prove double this, and that it will have to be taken away by dredging, the cost of doing so would be from 250,000 francs (£10,000) to 375,000 francs (£15,000) annually.

3. It has been urged that the Bitter Lakes, through which the canal is to pass, will be filled up with salt.

In addition to the current referred to from the Red Sea into and out of the Bitter Lakes, northerly winds will cause the water of the Mediterranean to find its way into those lakes, and the water of the lakes to pass into the Red Sea, while southerly winds will have the opposite tendency. The waters of the seas and of the lakes will therefore interchange and mix.

The evaporation from the surface of the Bitter Lakes, amounting in one year say to 3 metres (10 feet nearly) in depth, and the salt contained in sea water being about $3\frac{1}{2}$ per cent. of its weight, it follows, that if the *régime* of these lakes were such that the entire quantity of salt from 3 metres (10 feet nearly) in depth of water were thrown to the bottom, it would create a yearly deposit about ·07 metre ($2\frac{3}{4}$ inches) thick.

But sea water, before it would deposit salt, would have to be reduced by evaporation to at least $\frac{1}{10}$th of its original bulk. It is therefore obvious, referring to the currents before alluded to, into and out of the Bitter Lakes, that no such quantity as this could by any possibility be deposited, nor is it probable that any will be; but were it otherwise, any small accumulation of salt could readily be removed by dredging.

4. It has been urged that the navigation of the Red Sea is dangerous and difficult.

As to how far this objection may affect sailing vessels I can offer no opinion further than to say that such vessels, unless assisted by steam power, might, between Suez and Raz Mohammed (at the entrance of the Gulf of Suez), lose much time.

Captain Harris, who was one of the International Commissioners, and who is stated to have made seventy voyages between Suez and Calcutta, appears to have been of opinion that between Raz Mohammed and the Straits of Bab-el-Mandeb, the Red Sea is not more difficult of navigation than the Mediterranean.

To steamers and to ships possessing auxiliary steam power, by which the canal would probably be chiefly used, the objection can have no weight, inasmuch as the steamers belonging to the Peninsular

and Oriental Steam Navigation Company have now for many years navigated this sea without difficulty.

On this nautical branch of the subject, I beg to refer to the very able and elaborate report already mentioned of the Commissioners appointed by His Majesty the King of Holland, and to the remarks of M. Larousse, contained in his paper (appended to the French edition of that report, published in 1860), entitled "*Considérations sur les Avantages du Canal de Suez, pour le Commerce du Nord de l'Europe.*" These documents go with great minuteness into the comparative advantages to the different classes of ships, of the route by the Suez Canal, and of that by the Cape of Good Hope. The labours of the Dutch Commissioners were directed to ascertain the effect which the completion of the canal would have upon the commerce of their own country. The results of their enquiry therefore require modification to adapt them to the circumstances of other nations. Their report and M. Larousse's observations upon it, will well repay a perusal by any who may wish information as to the navigation by the Red Sea.

5. It has been urged that shipping will not approach Port Said, because of the difficulties that will be met with and the danger off that Port on a lee shore.

This is also an objection which could not apply to steamers nor to ships possessing auxiliary steam power. They could have no reason to hesitate lying off the Port when necessary, nor any difficulty in entering when required. When I was at Port Said, at least twenty sailing vessels were lying there under no apprehension of danger.

The prevalent winds are from the N.N.W. to W.N.W., and for more than one half of the year they blow from these directions.

The strong gales usually commence from the south-west, and extend round to W.N.W. Northerly winds are less violent; easterly winds are rare and generally feeble.

The roads off the Port are protected from winds blowing from south-east round by the south to north-west, and are exposed to winds blowing from north-west round by the north to north-east.

As far as my enquiries extended, I ascertained that there are not more than four or five gales in a year of any magnitude affecting that Port, and these gales are not such that would require any extraordinary care on the part of sailing vessels.

The anchorage at Port Said is undoubtedly good, and on the occasions of on-shore gales the shipping would have a sufficient offing to enable them to get away.

6. It has been urged that it will be difficult, if not impracticable, to keep open the Mediterranean entrance to the canal.

This objection is one requiring much consideration, and I have bestowed a great deal of attention upon it.

Several reports have been made to the British Admiralty on this subject by Captain Spratt, R.N. That distinguished officer is of opinion that a large amount of sand comes down the Nile and travels from west to east, past the entrance of the proposed canal—that this sand would tend to choke up the entrance to the canal, and that it would be very difficult to prevent this result by dredging. Captain Spratt is also of opinion that not only the sand on the shore at Port Said and in the Bay of Pelusium, but also that the pieces of broken pottery, which are occasionally met with in those localities, are all from the Nile; and he is further of opinion that this sand cannot have come from the sea coast, because the rocks lying to the westward on that coast are calcareous, while the sands at Port Said and the Bay of Pelusium are silicious. He adds, that the upper crest of the hills which embrace the Nile valley is composed of quartzoze rock, and he shows that the sea sand near Alexandria is chiefly calcareous.

On the other hand, M. Mougel Bey, a French engineer, for many years engaged upon important engineering works in Egypt, among others, upon the great work of the Barrage, in his published reply to Captain Spratt's Report, asserts that the sand at Port Said comes from the sea, and that Captain Spratt is wrong in most of his conclusions.

And M. Larousse, who was charged in 1860 by His Highness the late Viceroy to survey the mouths of the Nile, informed me that during the time he was so employed he made constant and regular observations of the matter deposited by the river, both in the interior and exterior of the Bars, and that he found it invariably composed of argillaceous particles, mixed with exceedingly fine silicious particles, which were totally different from the sands of the sea shore. From his observations M. Larousse draws the conclusion that the amount of sand brought to the sea shore by the Nile can only be very small, and that consequently, the deposits of the Nile will not add much to the difficulty of the maintenance of Port Said.

In order to determine the true state of the case, I collected sand from different localities, and the following is the result of the analysis to which they have been submitted by an experienced chemist;—

	Sand from sand hills on west side of Mex quarries.	Sand from shore between Mex quarries and Alexandria.	Sand from shore of new harbour at Alexandria.	Sand from shore 3 miles east of Alexandria.	Sand from shore 1 mile east of Ramleh.	Sand from shore west end of bay of Aboukir.	Sand from sand hills at Rosetta.	Sand from Port Said, west side.	Sand from Port Said, east side.
Carbonate of Lime . .	90·570	93·016	76·334	85·034	63·276	43·528	0·405	4·560	1·112
Carbonate of Magnesia .	3·948	3·040	4·725	7·325	5·111	5·241	0·107	0·200	0·653
Sulphate of Lime . . .	0·430	0·347	0·023	0·025	0·462	0·287	trace	trace	trace
Silica and Oxide of Iron	1·057	0·872	0·910	0·715	0·830	1·775	1·130	0·357	0·775
Insoluble residue . . .	3·800	2·890	17·798	6·550	30·790	49·370	97·958	94·607	96·680
	99·805	100·192	99·790	100·249	100·469	100·201	99·600	99·724	99·220
The above insoluble residue contains—									
Silica	3·100	2·504	14·232	5·775	28·164	43·760	84·310	89·839	85·500
Lime	0·150	0·064	1·334	0·100	0·400	0·750	4·300	0·831	3·010
Oxide of Iron & Alumina	0·500	0·302	2·010	0·741	2·180	4·687	8·874	3·630	8·000
	3·750	2·870	17·576	6·616	30·744	49·197	97·484	94·300	96·510

This analysis shows that the sand near Alexandria is more calcareous than that in the Bay of Pelusium.

But the mere establishment of this fact does not justify the conclusion that the silicious sand comes, either wholly or principally, from the Nile, for though the rocks, which form the coast line near Alexandria, and are visible on the sea shore westward of that Port, and eastward as far as Ramleh, are calcareous, yet so also all the rocks, in the region of the Nile lying northward of a line drawn from Gebel Attaka to the Pyramids, are, with very small exceptions; calcareous. How much higher the same description of rock extends I cannot from my own observation say; but I have no doubt, for a considerable distance. If however they reach no farther, it is evident that analysis affords no greater authority for saying that the silicious sands of the Bay of Pelusium come from the Nile than from the sea shore.

In addition to the sand on the coast, I also had the following calcareous rocks analysed, and the result proved that they contained silex. The following is this analysis:—

	Rock from Mex quarries.	Rock from Sea shore at Mex quarries.	Rock from sea shore 5 miles east of Alexandria.
Carbonate of Lime	95·827	86·523	82·870
Carbonate of Magnesia	1·300	0·783	1·010
Sulphate of Lime	0·070	0·089	0·100
Silica and Oxide of Iron . . .	0·980	2·430	1·106
Insoluble residue	1·191	9·915	14·350
	99·368	99·740	99·436
The above insoluble residue contains—			
Silica	1·020	7·910	13·090
Lime	0·060	1·350	1·020
Oxide of Iron and Alumina . . .	0·100	0·500	0·180
	1·180	9·760	14·290

When first the abraision of the rocks took place, the material would be chiefly calcareous: bnt as it travelled further from its parent rock, the calcareous matter would gradually disappear, whilst the silicious particles would remain. The fact therefore of the sand losing its calcareous character, is only an indication of age, and does not disprove its origin from calcareous rocks, any more than the circumstance of the flint shingle on the south coast of England, being found unmixed with chalk, disproves its relationship to the chalk cliffs of Dover or other localities, which contain the flint from which the shingle derives its origin.

The river Nile, however, within the limits I have indicated, nowhere at the present day shows rocks upon its margin, nor is there any place within the same limits, except for a short distance, say 3 kilometres (about two miles) on the left bank near Rosetta, and for the same length below Damietta, where sand hills touch the river. The banks of the Nile are of the same description of silt as that which covers the cultivated portion of Lower Egypt. This bed of silt, however, overlies a deposit of sea sand.

Now the Nile, which rises in highest floods at Cairo, 8 metres (26¼ feet), rises only 1 metre (3¼ feet) at its mouths near Damietta and Rosetta, and a very considerable proportion of its waters are, below Cairo, led away by canals into the region of cultivation, and pass thence, through the shallow lakes that border the Mediterranean, into that sea. The consequence is that the surface of the Nile loses its declivity as it approaches the sea, its velocity therefore diminishes, and it is only the finer particles that are carried forward, with which it is as it has been for years extending its delta; these fine particles are mainly of the same material as that which forms the surface now under cultivation.

In my examination of the sea coast, I found that the soft calcareous rocks from near Ramleh, as far westward as I travelled, are being worn away by the action of the sea. Ancient tombs near Alexandria, cut out of the solid rock, have in consequence now nearly disappeared; and east and west of Alexandria there are other indications of a similar kind.

I also noticed, when following the coast, larger accumulations of sand and a greater quantity of broken pottery between Alexandria and the Bay of Aboukir, than exist anywhere between the eastern or Damietta mouth of the Nile and Port Said.

It is just as probable therefore, that the sand at Port Said comes from the sea shore, where there is an obvious source of supply, as from the Nile, where within an equal or greater distance there is none so visible. Some sand, however, may come down

the Nile. The cultivated Delta below Cairo rests, as before mentioned, on a bed of sea sand, and a portion of it may occasionally find its way again to sea. But the process now going on seaward is probably more in accordance with that which formed the fertile land, viz., the covering of sea sand and other marine deposits by the fluviatile and lighter matter brought down by the river.

The presence of pottery in the Bay of Pelusium may be accounted for in various ways. Lake Menzaleh abounds with the ruins of towns from which pottery may have found its way to the sea coast through the several mouths (Boghazes); or, what is just as likely, from the circumstance of the sea coast having probably for thousands of years been used as a highway, along which Egyptians, ancient and modern, have travelled, who occasionally, as is the custom at the present day, carried pottery with them. It is not surprising, therefore, that broken pottery should be met with on so ancient a route.

The question, however, as to whether the sand found in the Bay of Pelusium comes down the Nile or from another source is a subject interesting more as a scientific enquiry than as a point influencing the decision of the question affecting the canal. It is not very material to the discussion to determine whether all the sand comes down the Nile, as Captain Spratt supposes, or from the sea, as is the opinion of his opponents; but as the question has been made a prominent feature, and has been much discussed in connection with the canal, it was necessary to make a few remarks thereon. Evidently the important question to the canal is to ascertain—

a. Whether the sand travels from west to east, or in the contrary direction.

b. Whether or not it travels in large quantities.

My investigations have led me to the conclusion that whilst some small quantity of sand—by which I mean silicious particles large enough to constitute such sand as is met with at Port Said—may find its way into the sea from the Nile, a larger quantity has been and is still being brought by the sea itself from the abrasion of silicio-calcareous rocks which form part of the coast, and that probably the greater portion of this sand is merely the continuation or visible margin of that which, as before mentioned, lies under the muddy deposit of the Nile. And that whether the sand come from one or both sources, there is no doubt that it travels from west to east, and the quantity that finds its way past Port Said is not large.

But though I have arrived at this conclusion, relative to the source from which the sand principally comes, I quite agree with Captain Spratt that the Delta of the Nile is, as I have before stated, extending itself seawards, but I believe this extension to be of mud commonly so called.

The jetties proposed to be constructed at Port Said would obstruct such sand as might come there, which would form a bank to the westward of the western jetty. In process of time, long enough to be disregarded, it might possibly overlap the northern end of the jetty, which, in that event, would have to be lengthened. In like manner the gradual extension of the Delta of the Nile northwards into the Mediterranean might ultimately require an extension of the jetties, but this is a process which, though geologically speaking rapid, is too slow to be material in an engineering point of view.

In the meantime any deposit that might take place within the jetties at Port Said could readily be removed by dredging, and should it hereafter be found desirable to call for the aid of an outward stream to assist in keeping the entrance clear, the water from Lake Menzaleh could without difficulty be applied for that purpose. It would only be necessary to shut up the Gemileh mouth, where, when I saw it, there was a current into the sea of 3 kilometres (2 miles) an hour, and make an opening from the lake into the canal above Port Said, when for many months in the year an outward current of clear water would be secured which would scour the entrance.

CONCLUSIONS AS TO PRACTICABILITY OF CONSTRUCTION AND OF MAINTENANCE.

Having now reviewed the several matters connected with the engineering construction, and with the maintenance of the canal, I have arrived at the following conclusions:

Firstly. As regards the engineering construction there are no works on the canal presenting on their face any unusual difficulty of execution, and there are no contingencies that I can conceive likely to arise that would introduce difficulties insurmountable by engineering skill.

Secondly. As regards the maintenance of the canal, I am of opinion that no obstacles would be met with that would prevent the work, when completed, being maintained with ease and efficiency, and without the necessity of incurring any extraordinary or unusual yearly expenditure.

COST OF CONSTRUCTION AND MAINTENANCE.

I would willingly have confied my report to the questions of the practicability of the construction and of the maintenance of the Ship Canal, of which I have no doubts whatever, and have avoided giving (what is somewhat hazardous with my amount of information) an estimate of cost; but I feel the Egyptian Government is entitled to such opinions as I entertain on this point, and I have, therefore, to state what occurs to me thereon.

As regards the cost of construction, the question of estimate will have to be modified in accordance with the observations I have previously made on the points directly affecting it, and it will stand as follows:—

	Francs.	£
Total capital proposed to be raised . .	200,000,000	8,000,000
Earthwork saved	12,000,000	480,000
	188,000,000	7,520,000
Add for protective works through Bitter Lakes	7,000,000	280,000
	195,000,000	7,800,000
Add for pitching bottom and slope of canal from Red Sea to Bitter Lakes . .	12,500,000	500,000
	207,500,000	8,300,000
Add further sum, probably needed for interest on the capital during construction	20,000,000	800,000
Total	227,500,000	9,100,000

Looking, however, to the money already expended, compared with the work done, and considering the contingencies connected with the possibility of meeting with rock at the Red Sea entrance, and that the deep dredging in the canal, and at the Mediterranean entrance, may cost more than the estimated amount, and also looking to the contingencies incident to an undertaking of such magnitude as the Ship Canal, I should think it prudent for you to assume that, before it be fully finished and perfected, the expenditure, including the additional cost of the modifications I have suggested (should the whole of them be adopted), together with land purchases and cost of buildings, may reach 250,000,000 francs (£10,000,000).

In this estimate I assume that the time within which the canal will be opened for traffic will not exceed 5 years. I have, however, given no credit for revenue arising from rental that may be derived from the lands and dwelling houses of the Company.

As regards the cost of maintenance the International Commissioners entered upon that subject in detail, and estimated that a yearly expenditure of 1,570,498 francs (£62,820) would be sufficient for the purpose. I see no reason to differ from that conclusion.

HARBOUR OF TIMSAH.

Before bringing my observations on the Ship Canal to a conclusion, it will be necessary for me (in order to comply with the request of His Highness, the late Viceroy) to give my opinion, relative to the suitability (in an engineering point of view) of Lake Timsah, for the establishment there of an Inland Harbour.

Lake Timsah is already a basin usually dry, having an area of about 30,000,000 square metres (35,881,000 square yards). Its general level is depressed below that of the Mediterranean, to an extent varying from about 2 metres (6½ feet) to 4 metres (13 feet).

The Fresh Water Canal will pass near to it, and thus a ready supply of fresh water will be obtained.

When the Ship Canal is completed and filled with water, Lake Timsah will also be filled to the same level: it will, therefore, become an Inland Basin. All that will be necessary to form a harbour, with requisite accommodation for shipping, will be to deepen the bottom of the lake in such places, and to such an extent as may be needed for the purpose; and to erect quay walls, and other necessary works, in suitable positions.

Lake Timsah, as a site, affords every facility for the execution of these works; but I am unable, with the information I possess, to form an opinion as to whether its inland position and locality recommend it for the purposes of shipping.

REPORT ON THE BASIN AND GRAVING DOCK AT SUEZ.

I have already said that these works are wholly unconnected with and independent of the Ship Canal. They are projected as an adjunct to the railway communication, and have been undertaken by the Messageries Impériales, who have entered into a contract with the Egyptian Government to complete them for a sum of 6,000,000 francs (£240,000).

The works consist of an extension of the railway by embankment into the Red Sea, and of the construction of a Basin, and also of a Graving Dock. The railway will be laid on the sides of the Basin, where there will be a sufficient depth of water for the packets of the Peninsular and Oriental Steam Navigation Company to enter. Thus the passengers and cargo will be delivered and received directly to and from the railway, and the fuel will be brought alongside.

At present these packets cannot approach within 5 kilometres (3 miles) of Suez, and all the passengers, cargo, and fuel have to be conveyed between the packets and the railway by boats and small steamers.

The projected Basin and Graving Dock, together with the railway communication, are shown upon plan No. 2.

The length of the railway will be about 5 kilometres (3 miles).

The Basin is intended to be 450 metres (1,476 feet) long, 250 metres (820 feet) broad, and 7 metres (23 feet) deep below the mean level of the sea.

The Graving Dock is to be 120 metres (393 feet) long, 29 metres (95 feet) wide at the top, and 23 metres (75 feet) wide at the bottom, and is to be constructed at the upper end of the Basin.

The stone, for the masonry and *Pierre Perdue*, is to be procured from the quarries at Attaka, which are close at hand.

The estimate is made up as follows:

	Francs.	£
Works	5,400,000	216,000
Administration	450,000	18,000
Premium to Contractors for early completion	150,000	6,000
	6,000,000	240,000

The time of completion may be assumed to be three years from 1st September, 1862.

I have examined the prices of the proposed work, and see no

reason why they should not prove sufficient. The only risk on this point, appears to me to be the chance of meeting with rock in the portion of excavation that must be done by dredging. M. Stoecklin, the engineer to whom the direction of the work is entrusted, seems confident, from investigations already made, that there is no risk on this point. Additional borings were being taken when I was at Suez, at the place where the dredging will be required. And as the area to be dredged is not large, it is possible that a few more borings may remove all doubts on the subject.

The Basin and Graving Dock appear to me to be well designed for the object in view. There is no peculiar engineering difficulty likely to be encountered in their execution. And when completed, and the Railway extended to them, they will tend very much to facilitate the overland transit to India.

JOHN HAWKSHAW.

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Nº 1.
SUEZ CANAL
General Map.
MEDITERRANEAN
ROSETTA
ALEXANDRIA
LAKE MAREOTIS
PORT SAID
ISMAILIA
TIMSAH
SUEZ
CAIRO
ZAGAZIG
DESERT
RED SEA

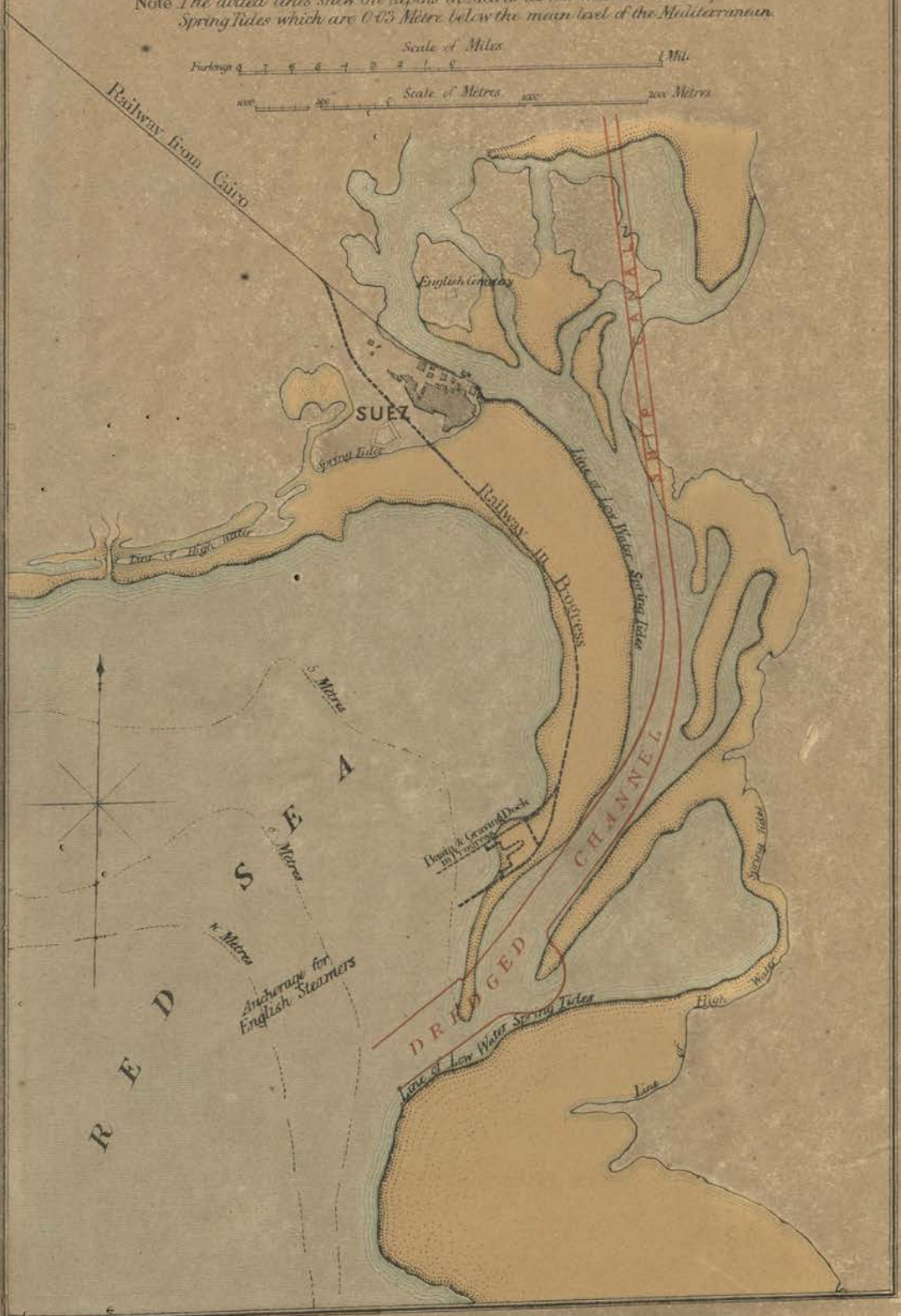
Nº 2.

SUEZ CANAL

PLAN OF RED SEA ENTRANCE AT SUEZ.

Referred to in Mr Hawkshaw's Report Dated February 3rd 1863.

Note The dotted lines show the depths in Metres at low water of Ordinary Spring Tides which are 0·03 Metre below the mean level of the Mediterranean.



Cary Lange Lith. 10 Ring St. & 4 Trafalgar Square Regent's Canal

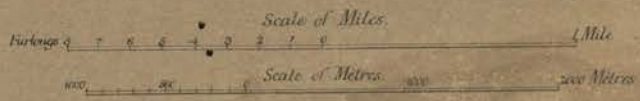
No 3.

SUEZ CANAL

PLAN OF MEDITERRANEAN ENTRANCE AT PORT SAID

Referred to in Mr Hawksshaw's Report Dated February 3rd 1863

Note *The dotted lines shew the depths in Mètres below the mean level of the Mediterranean*



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